A123 Systems' Energy Storage Projects & Applications Overview

California Energy Commission,
Lead Commissioner Workshop on Renewable Integration Costs, Requirements, and Technologies

June 11, 2012

Storage for Renewable Integration

- Technology is not a barrier
  - Track record of using storage for grid benefit, 20,000 MW of P.S.
  - **Unique attributes of new *Fast, Modular, Flexible, and Accurate Advanced* Energy Storage introduce new solution options and value-add opportunities**
- Cost is not a barrier
  - But, does limit opportunities right now
- Regulatory Rules for Storage, needs work
  - G or T or D - who invests and mechanisms for investment recovery?
  - Operating experience will support policy effort focus & investment
  - **Modeling in CAISO and CA IOU and Muni utility transmission and resource planning studies will expand consideration and incorporation of effective storage alternatives**
    - Load Flow and Dynamic Stability
    - Production Simulation

>90 MW of A123 Advanced Battery Systems Performing Grid Applications

Completed installations:

- Nov 2008 – 2MVA/500kWh, California (to PJM '12) **Frequency Regulation**
- Nov 2009 – 12MVA/4MWh, Atacama, Chile …… **A/S, and release generation for energy**
- Oct 2010 – 400kVA/100kWh, Denmark …….. **Wind Ramp Rate Control**
- Jan 2011 – 20MVA/5MWh, New York …….. **Frequency Regulation**
- Sep 2011 – 32MVA/8MWh, W. VA/PJM …….. **A/S, and Renewable Integration**
- Oct 2011 – 4MVA/1MWh, California …….. **Smart Grid Resource (Multi-T&D Services)**
- Nov 2011 – 20MVA/5MWh at Angamos, Chile …… **A/S, and release generation for energy**

Under construction:

- Aug 2012 – 500kVA/125kWh, China …….. **Renewable Integration Demo**
- Jun 2012 – 2MVA/500kWh, Massachusetts …….. **Frequency Regulation**
- Aug 2012 – 8MVA/32MWh, Tehachapi California.. **Grid-Side Wind Integration Demo**
- Sep 2012 – 500kVA/250kWh, Detroit …….. **PV Integration Demo**
- Oct 2012 – 11MW/4.4MWh Maui …….. **Wind Ramp Rate Control**
- Nov 2012 – 1MVA/3MWh, Europe …….. **T&D Support, Load Shifting & Voltage Reg.**
- Dec 2012 – 1MVA/1MWh, Maui …….. …….. **T&D Support, Load Shifting & Voltage Reg.**
- Dec 2012 – (1) 5MWh & (5) 100KWh systems, U.K. **T&D Support, Load Shifting & Voltage Reg.**

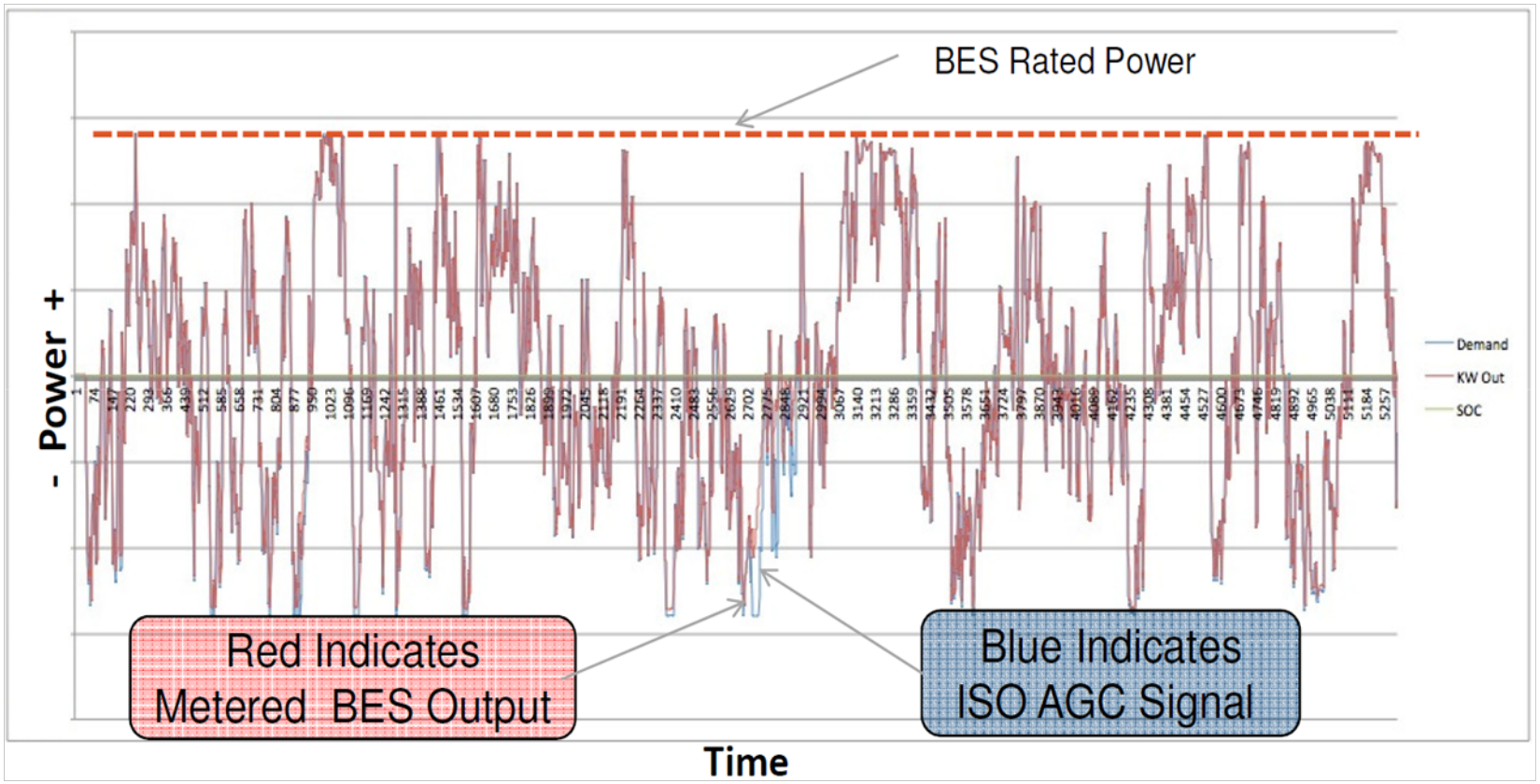
Traditional Storage is a vital grid resource today at 20 GW of Pumped Storage

Advanced Storage is growing . 170 MW per DoE, http://www.energystorageexchange.org/

Frequency Regulation & Wind Integration: 32 MW, PJM, commercial operation 2011

Photo courtesy of AES Storage

Frequency Regulation (F/R): Sample Output

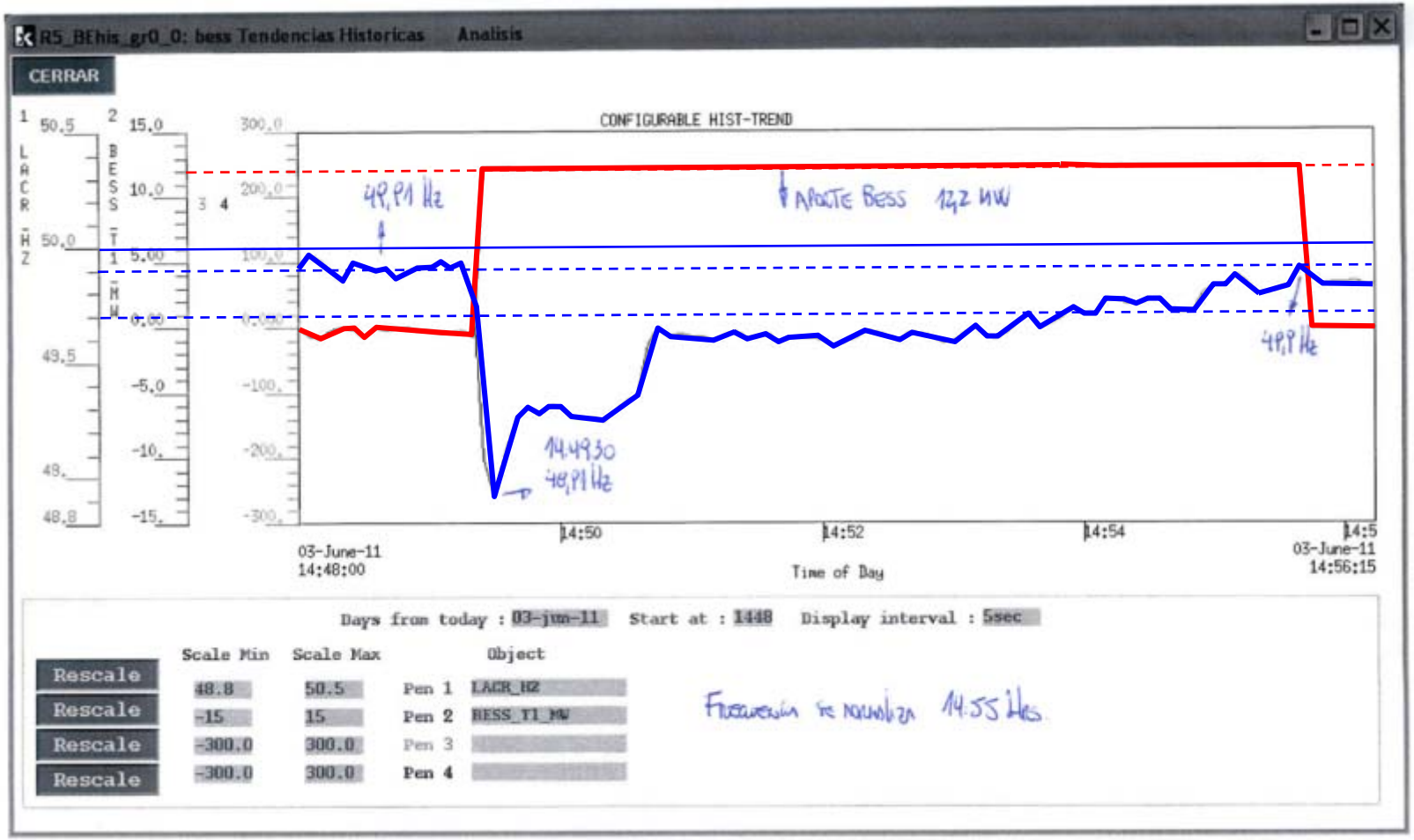


Faster and more accurate response = better grid system performance, and lower total cost for meeting F/R Ancillary Service requirement

Spinning Reserve for Generation Capacity Release: Chile, 12 MW 2012, 20 MW 2011

Chile System, A123 Response to Grid Outage

CDEC-SING Fault Report No. 2777, June 3, 2011

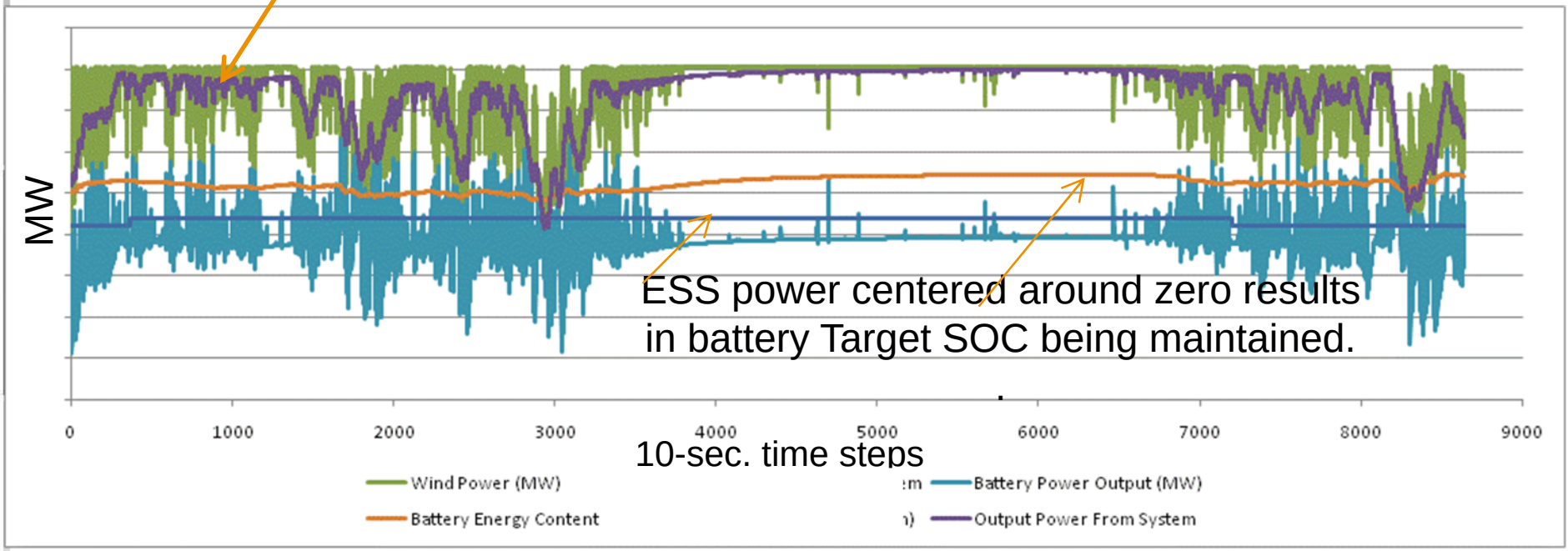


Renewable Integration Pilot – Denmark 2011

Ramp Rate Management demo system

Storage for Meeting Ramp Rate Control Req't

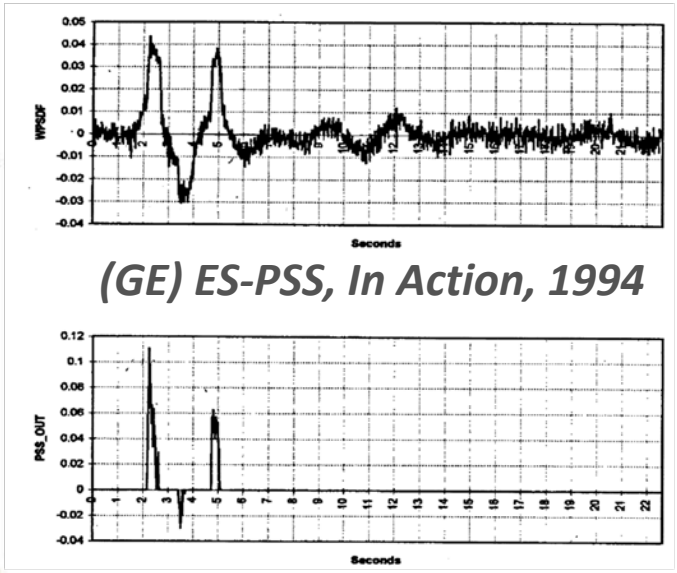
Net power delivered to grid **meets performance requirements**



Extending *Advanced* Storage App's to Bulk Transmission And Regional Support

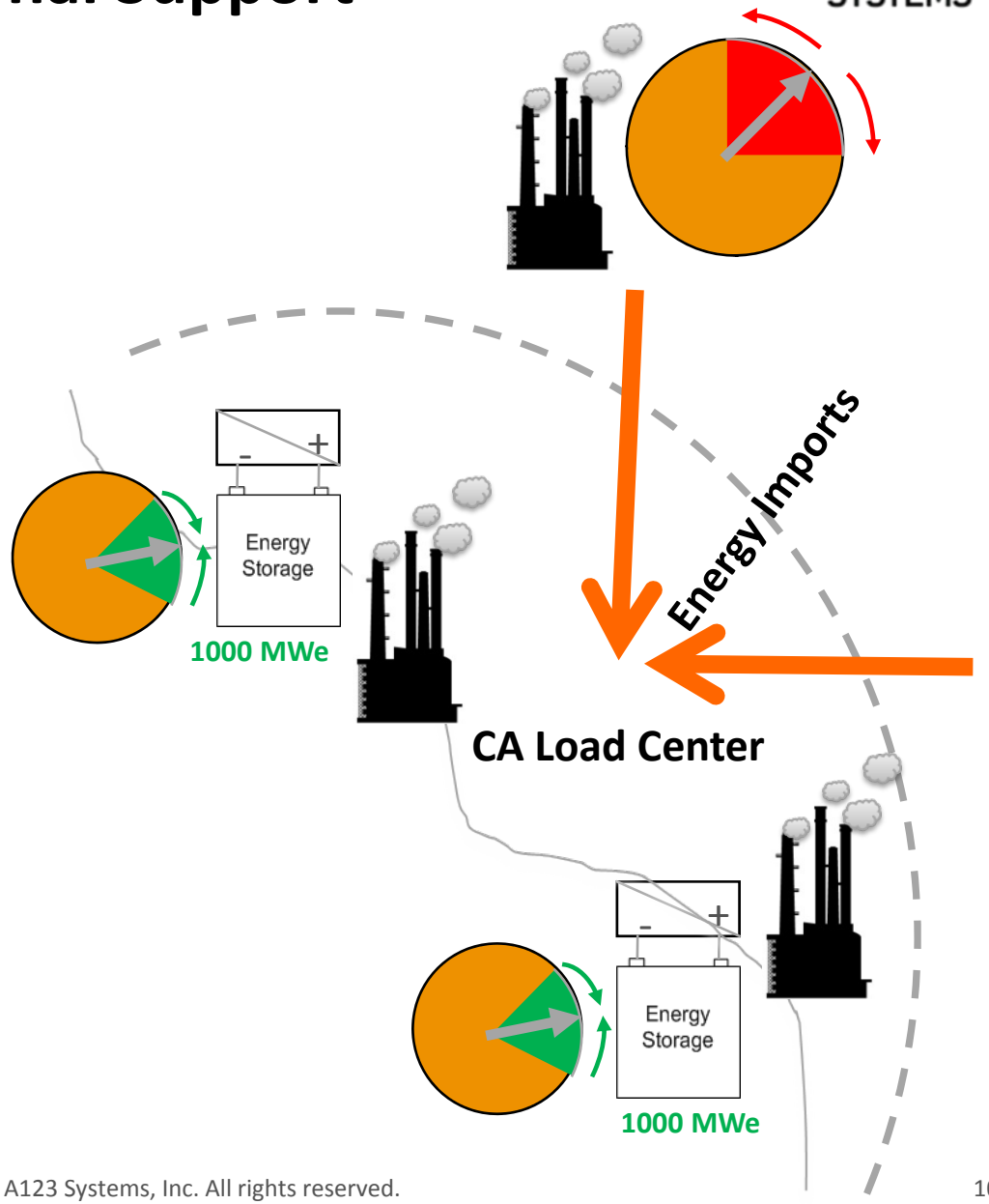
PMU-equipped Storage Systems Detect and Damp Inter-area Oscillations.

Higher Dynamic Stability Limit = More Useable Transmission & Import Capacity



(GE) ES-PSS, In Action, 1994

Source, SCE, EPRI

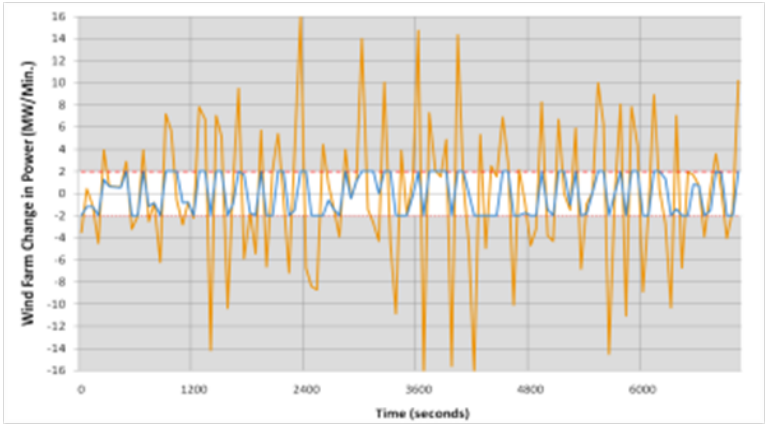


BACKUP SLIDES

Applying Energy Storage to Electric Grids

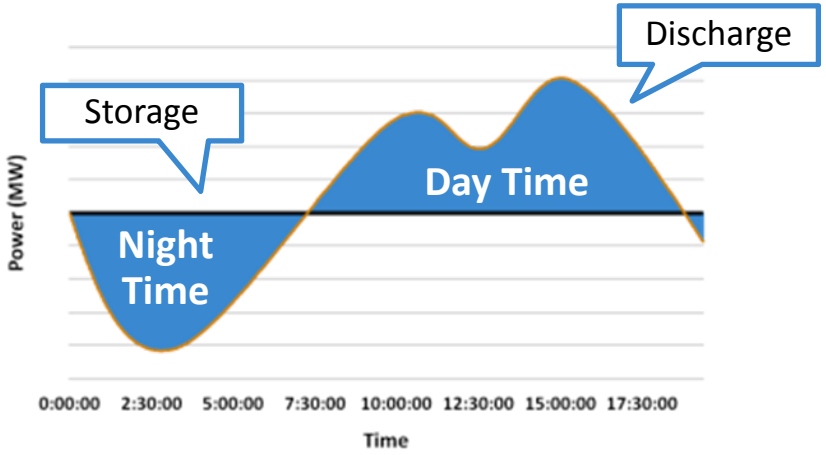
Multiple Applications for Grid Storage

High Power Applications:



- Regulation
- Spinning Reserve
- Renewable Integration
  - Ramp Management
- **Requirements:**
  - Very high Charge/Discharge Rates
  - Short Duration (<1hr)
  - Many cycles (100s per day)
  - Continuous use

High Energy Applications:



- Peak Load Shifting
- Renewable Integration
  - Firming, Shifting & Curtailment Recovery
- Energy Arbitrage
- T&D Asset Support
- **Requirements:**
  - Minimum Size(1+ hrs of energy)

Systems Engineering

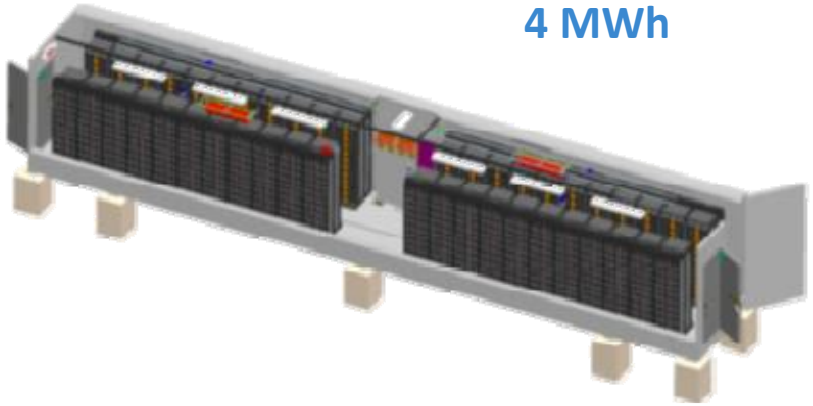
A123's Expanding System Options

High Power Applications

GBS-C-53
0.5 MWh

High Energy Applications

GBS-P-53
4 MWh



- Frequency Regulation
- Reserve
- Renewable Ramping
  - + Enabling Access to Full Energy Value

- Peak Shifting and Arbitrage
- Renewable Integration
- Firming, Shifting & Curtailment Recovery
- T&D Support & Investment

Spec's for Standard GBS-P and GBS-C Systems

	Long-Duration (LD) Grid Battery Systems			High-Rate (HR) Grid Battery System
Model Number	GBS-C53-LD40	GBS-C40-LD28	GBS-C20-LD12	GBS-C53-HR20
Energy Storage	4 MWh (nominal at C/2 rate)	2.8 MWh (nominal at C/2 rate)	1.2 MWh (nominal at C/2 rate)	700kWh (nominal at 1C rate)
Power Rating	4 MW	2.8 MW	1.2 MW	2 MW
Dimensions (LxWxH)	53' x 8.5' x 9.5' (16.2m x 2.6m x 2.9m)	40' x 8.5' x 9.5' (12.2m x 2.6m x 2.9m)	20' x 8.5' x 9.5' (6.1m x 2.6m x 2.9m)	53' x 8.5' x 9.5' (16.2m x 2.6m x 2.9m)
Mass	141,000 lbs	103,000 lbs	49,000 lbs	64,000 lbs
DC Efficiency*	97% (C/2 rate)			96% (1C rate)
DC Voltage	944V nominal (750V – 1050V DC operating range)			960V nominal (750V – 1050V DC operating range)
Ambient Operating Temperature Range	-30°C to + 50°C			
Enclosure details	Containerized, ISO 1496-1 certified, IMO CSC-compliant, designed to IP56 per IEC60529			

* Inclusive of battery management electronics; excluding auxiliary power consumption by thermal management systems. Long-Duration GBS efficiency measured at full depth of discharge. High-Rate GBS efficiency measured at partial depth of discharge near mid state-of-charge.

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